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ABSTRACT

An analysis of the cognitive and affective outcomes of individualized programmed experiments (IPE) on seventh-grade pupils was performed. Based on the theory that student attitudes towards mathematics are largely shaped during the period of time spanned between fourth through eighth grade, researchers investigated the effectiveness of nonlecture teaching methods on the attitude and subsequent mathematics achievement of 29 male and 25 female junior high school students. Results were compared to the findings of previous work in the field. A tentative conclusion of the research states that IPE had no harmful effects on the treatment group. (LH)

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A Study of the Effects of Individualized Programmed Mathematics Experiments on Achievement and Attitudes of Seventh Grade Students

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A Study of the Effects of Individualized Programmed Mathematics Experiments On Achievement and Attitudes of Seventh Grade Students

Introduction

During recent years, considerable attention has been focused on the improvement of teaching mathematics. If a student is to succeed in a high school mathematics program, it is imperative that an understanding of mathematical concepts be achieved by the completion of eighth grade. Moreover, testimony from research strongly suggests that students' probability of success in secondary school mathematics is influenced by attitudes formulated toward the subject while in elementary and junior high school.

Admittedly the mastery of basic mathematical concepts is an important factor for success in mathematics beyond junior high school, but attitude is also a highly significant factor, indeed the literature indicates that attitude plays a crucial role in learning mathematics (Aiken, 1976). The child's attitude according to Capps and Cox (1969) affects what he learns, what he does, and what he remembers. Hence, the development of positive attitudes is central in guiding a child's mathematical development. Dutton, (1962) concluded that although feelings toward mathematics are developed in all grades, the most crucial years for developing an attitude for or against mathematics are while pupils are enrolled in grades 4-8.

The manner in which mathematics instruction is implemented (including materials) may be a significant factor in how well students

master basic concepts and the kinds of attitudes developed toward mathematics prior to entering high school.

Statement of the Problem

The problem was to analyze cognitive and affective outcomes of individualized programmed experiments (IPE) on seventh-grade pupils by examining the discriminating effectiveness of pre/posttest arithmetic and attitude measures.

Definitions

Individual Programmed Experiments (IPE): Single-concept activity-oriented materials in which students engage by systematically manipulating designated materials in order to respond to mathematical questions. The subject follows a carefully delineated set of directions to experiment with concrete materials in a step-by-step procedure which enables the pupil to sequentially develop sub-concepts, respond to specific intermediate questions, and ultimately establish a basis for responding to a more generalized mathematics question.

Perhaps the major considerations which distinguishes IPE from other types of programmed instruction are:

1. IPE emphasizes the sequential development of key mathematical ideas through experimentation rather than an abstract approach void of concrete devices.

2. IPE emphasizes an appropriate balance between fundamental skills and reasoning ability rather than a major focus on remembering of facts and extensive computation.

3. IPE consists of verbal materials carefully prepared by the authors along with a group of elementary and junior high school teachers.

Verbal Materials: Materials depending upon written or spoken language or both (Redgrove, 1967).

II. REVIEW OF RELATED RESEARCH

A review of research literature published during recent years immediately reveals an unprecedented interest and concern about the use of Programmed Instruction (PI) in mathematics. This growing body of knowledge has not only answered some questions but has raised additional issues as well.

Among the research reported in this study, one finds that attention has been focused on a variety of approaches, types of programs and materials, variables studied, samples, length of study, and statistical treatment of data.

In view of the diverse interests among researchers, there is a lack of complete agreement on the use of PI and, thus, there is little basis for generalizing about certain kinds of PI.

Because some studies indicated the superiority of programmed instruction and others indicated inferiority, some researchers turned their attention to characteristics of the learners as a possible source of explanation of the lack of unequivocal results. Spagnoli (1965) found that two sixth-grade classes did as well with programmed materials as did two control classes. In comparing a linear type program to a modified traditional format, Beane (1965) used four groups of twelve students as a sample. The analysis of achievement scores indicated no significant differences between the treatments and the high and low levels of ability.

Bantz and Darby (1966) using 147 subjects, investigated the achievement of students using programmed or non-programmed texts

under traditional techniques of instruction. The Ss were assigned to twelve groups differing in type of text used, instructional technique employed, and instructor. Results indicated that Ss under the traditional instructional technique performed significantly higher on achievement than did Ss under independent study (.05 level of significance). The Ss using non-programmed text did significantly higher than did Ss using programmed text.

Belcastro (1966) prepared two mathematics programs and administered to four hundred eighth-grade students in four junior high schools during three school days. The programs were of four forms: (a) verbal inductive, (b) non-verbal inductive, (c) verbal deductive, (d) non-verbal deductive. Belcastro found the deductive form superior to the inductive and the verbal mode superior to non-verbal. On all dimensions, there were no significant differences.

Several studies have been concerned with comparisons of program styles, types of responses, etc. Among these Terkeurst (1965) has offered cogent reasons for altering the nature of multiple-choice responses when a program involves the discovery concepts. His suggestion is that three or four responses be correct ones and task of the student be to select the incorrect response. It is suggested that knowing and understanding what is included in a concept is far more important than what is excluded. With regard to concepts, reasoning, etc., Terkeurst (1965) found intrinsic programmed method (as contrasted with linear or branching programs) was an effective aid in teaching of concepts, principles, reasoning, etc.

An investigation of changes in attitudes and total achievement in arithmetic as reported by Jones (1968) reveals that the use of a modified programmed lecture approach produced significant results.

An experiment by Niedermyer, et al. (1969) compared three sequence versions (Logical, scrambled, and reverse frame orders) of PI, number series, which had been used by Gagne and Brown in their 1961 study. Sixteen ninth-grade algebra students in each of the three sequence groups plus a control group served as the subjects. While the logical order group was the only sequence group to perform significantly better than the controls on both a test of concepts and a problem test, none of the three groups differed significantly from each other on post-test performance. The logical group did, however, make significantly fewer program errors. They also tended to exhibit a "positive attitude," whereas the other groups appeared to have been "neutral" about the program.

An important issue to researchers in the area of PI has been whether the mode of responding to an instructional program gives rise to achievement differences. Constructed-response described those Ss who construct (write down) their answers to a program. Ss who "think" or "reason" the answer without actually writing it down (or performing computation) are identified as covert response. Basically, research confirms no general agreement on various modes of responding. For example, Williams (1963) demonstrated that constructed and multiple-choice response modes led to higher achievement. In a second study Williams (1965) with a different instrument and sample, found that differences were manifested only on a constructed-response and not on multiple-choice items.

The use of PI materials as a supplement to conventional textbooks has been reported by Lach (1970). His study was concerned with three

dimensions of assessment: achievement, interest, and attitudes. The results revealed no significant differences between groups.

III. PROCEDURES

Sample

One hundred twenty-one seventh-grade students comprising four groups at F[illegible]st Junior High School in Opelousas, Louisiana were pre-tested. From these four groups only two were identified as comparables and constituted the subjects for this study (25 girls and 29 boys). The randomly selected treatment group (N=27) used IPE materials for ten weeks while the control group (N=27) received instruction by conventional methods during the same period. Initially, the treatment and control groups contained 30 and 32 students respectively.

Instrumentation and Collection of Data

The dependent variable or criterion used in this study was defined in terms of whether a student received IPE or conventional instruction. Hence using this criterion of IPE vs conventional instruction (CI), an attempt was made to determine whether the independent variables could differentiate between the two groups.

The predictor variables (two congnitive and two affective) were: (a) Arithmetic Reasoning (AREAS); (b) Arithmetic Fundamentals (AFUND); (c) Attitude Toward Mathematics (ATM); and (d) Pupil's Estimation of Attitude (PEA). Measurements of cognitive variables were collected by The California Arithmetic Test (Junior High level), Form X. Raw scores were used rather than grade placement scores.

An attitude scale, constructed by Dutton, was used to secure data on affective variables. The scale consisted of two parts: one had

twenty-two statements of attitude toward mathematics and the other was designed to obtain the pupils' estimate of their general feeling toward mathematics by checking one number on a scale ranging from 11 (the extreme position for like) through 6 (neutral) to 1 (extreme for dislike). The twenty-two attitude statements contained weights ranging from 1.0 (greatest dislike) to 10.5 (extreme liking).

According to Dutton, the reliability of the scale measured by test-retest methods, was 0.94.

Analysis

After the date on the four variables were accumulated they were processed by the 66/60 Honeywell computer using a Multiple Stepwise Discriminant Analysis program. The computer first selected the "best" independent variable and then selected the "best" of the remaining variables from the pool of discriminating variables. This stepwise selection continued for all four variables in the analysis; computing F-ratios, intercorrelations, classifications of subjects, the means and standard deviations, and canonical values are computed in this scheme.

Predictions

The basic hypotheses in this study were that there were no significant differences between the IPE and CI groups relative to achievement in and attitude toward arithmetic. Accordingly, the following null hypotheses were subjected to statistical tests:

H_o1: There will be no significant difference between the two groups as revealed by any combination of the variable.

H_o2: There will be no significant difference between the two groups by sex on any combination of variables.

IV. RESULTS

The statistical treatment of data was achieved by application of the Multiple Stepwise Discriminant Analysis. Homogeneity of variance and normality of distribution were assumed.

Pretest means and standard deviations for the two groups are reported in Table 1 and suggest no significant separation between the groups.

TABLE 1
Pretest Means and Standard Deviations

	Treatment (N=27)		Control N=27	
Variable	Mean	SD	Mean	SD
AREAS	25.19	5.13	24.70	4.83
AFUND	32.52	6.72	33.63	6.77
ATM	43.81	20.28	43.56	19.18
PEA	8.11	1.87	8.44	1.93

Table 2 shows interrcorrelations between each pair of discriminant variables. Inspection of this table reveals (as would be expected), significant relations between cognitive variables and also between affective variables.

TABLE 2
Pretest Within Groups Intercorrelation Matrix

Variable	X_1	X_2	X_3	X_4
AREAS (X_1)	1.0000			
AFUND (X_2)	.6038*	1.0000		
ATM (X_3)	- .0579	-.1206	1.0000	
PEA (X_4)	- .0712	-.0452	.6664*	1.0000

*significant value of r at .01 level = .3541 (N=54).

To test the hypotheses, discriminant equations were computed in a stepwise manner in which the computer selected the "best" variable in hierarchal rank of variables in accordance to its contribution of group separation. Reference to Table 3 reveals that none of the variables achieved statistical significance at the .05 level or beyond.

Table 3
Pretest Summary of Entering the Results of Independent Variables into the Stepwise Discriminant Analysis

Discriminating Combination Selected	F	df	Number of Subjects Theoretically Classified CI	IPE
X_4	.4164	1/52	14 12*	13* 15
X_4 X_3	.4059	2/51	17 10*	10* 17
X_4 X_3 X_2	.3663	3/50	16 10*	11* 17
X_4 X_3 X_2 X_1	.4308	4/49	15 10*	12* 17

*Denotes number of subjects theoretically selected from the opposite group (amount of commonality or "overlap" among groups).

This means that the two groups were equivalent at the beginning of this study.

Further examination of Table 3 explains the lack of significant differences in that at each stop in the analysis approximately 40% or more of the subjects were shown to be very much alike on each combination of variables.

Additional analysis of pretest data were made with sex introduced as one criterion variable. Each of the two groups of subjects were subdivided as follows: Treatment groups consisted of 19 boys and 8 girls while 10 boys and 17 girls constituted the two control groups. Using these four groups of subjects, and the four predictor variables, an analysis was done for each of the six pairs of groups as was done for the original two groups. Except for a significance within group difference between control group boys and control group girls on the AREAS variable, the analysis revealed no other significant results and, therefore, were not reported here. Thus, all analysis confirms no initial differences between treatment and control groups.

After a treatment period of ten weeks the subjects were posttested using Form Z of the California Arithmetic Test and the Dutton Attitude Scale used for pretesting. These posttest data were treated using the same procedures as those used in the pre-test analysis.

Table 4 which reports the posttest means and standard deviations, indicates that significant differences are unlikely.

TABLE 4
Posttest Means and Standard Deviations

	Treatment (N=27)		Control (N=27)	
Variable	Mean	SD	Mean	SD
AREAS	27.26	5.32	27.56	8.19
AFUND	45.74	10.83	43.04	13.39
ATM	41.93	21.55	39.44	18.44
PEA	8.04	1.93	7.51	2.58

The intercorrelations between each pair of predictor variables, shown in Table 5, again reveals significant relationships between the pair of cognitive variables and the pair of non-cognitive variables. Additionally, there is a significant relation between ATM and AREAS. In fact, there is, in general, a much stronger relationship between each pair of variables on the posttest than reported from the pretest. The one exception is the ATM-PEA relationship which decreased between pre- and posttests.

TABLE 5
Posttest Within Groups Intercorrelation Matrix

Variable	X_1	X_2	X_3	X_4
AREAS (X_1)	1.0000			
AFUND (X_2)	.6532*	1.0000		
ATM (X_3)	.2816**	.2132	1.0000	
PEA (X_4)	.2433	.0524	.3459*	1.0000

*Significant value of r at .01 level = .3541 (N=54)
**Significant at .05 level.

TABLE 6
Summary of Entering the Posttest Results of Independent Variables into the Stepwise Discriminant Analysis

Discriminating Combination	F	df	Number of Subjects Theoretically Classified as: CI	IPE
X_4	.6998	1/52	12	15*
			12*	15
X_4 X_2	.7069	2/51	15	12*
			13*	14
X_4 X_2 X_3	.5042	3/50	17	10*
			11*	16
X_4 X_2 X_3 X_1	.3824	4.49	15	12*
			10*	17

*Denotes number of subjects theoretically selected from opposite group (amount of commonality or "overlap" among groups).

While Table 6 reveals no significant F-ratios, it is interesting to note that PEA was the "best" discriminating variable as a pretest and posttest variable. Moreover, it is important to note that in the pretest analysis PEA and ATM (X_4 X_3), the two attitude measures, were the second most powerful discriminating combination (See Table 3). However, in the posttest analysis, the combination of PEA and AFUND (X_4X_2) turns out to be the second most dominant discriminator.

Consequently, however, the discriminant combination which establishes maximum separation on both pre and posttest measures is X_4 X_3 X_2 as revealed in Table 3 and 6. But even this combination was not strong enough to establish significant differences between groups because 21 subjects (10 from IPE and 11 from CI), representing thirty-nine percent for the two distributions, displayed characteristics different from their actual group.

Thus, of 27 students actually belonging to the IPE group, seventeen exhibited characteristics associated with that grouping, whereas ten (thirty-seven percent) had characteristics more similar to the CI group. Likewise, of 27 students originally assigned to the CI group only sixteen had predominately CI characteristics while eleven (forty-one percent) displayed qualities similar to the IPE group. These figures graphically illustrate the lack of significant differences resulting from the experimental treatment. There is considerable commonality among groups as revealed by the extensive between group cluster about the four means by practically all subjects.

Accordingly, findings reported on this investigation dictate acceptance of all null hypotheses. Close scrutiny of this study,

however, reveals some significant implications and/or considerations for education. These are discussed in Section V.

V. DISCUSSION

This investigation was designed to test several null hypotheses concerning the effect of Individualized Programmed Experiments with seventh-grade mathematics students. In summary, it was hypothesized that there would be no significant difference between two groups of Ss relative to the individual or combined effects of the predictor variables.

A Multiple Stepwise Discriminant Analysis was conducted on the independent variables adopted for this study.

Although no variable(s) achieved significance, the dominant discriminator in pre and posttest analysis was PEA. Moreover, it should be noted that the posttest means and SD tend to favor the IPE group (which was not the case on pretest measures); and in the absence of evidence to the contrary, leads to the conclusion that IPE had no harmful effects on the treatment group.

The results of this study tend to agree with some prior research and at the same time differ from still other studies as reviewed in Section II of this report.

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